

Treatment of long bones with external fixation apparatus

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ABSTRACT

In modern traumatology, selection of optimal and appropriate methods of treatment for long tubular bone fractures, especially complicated, open, multiple and metaepiphyseal fractures, does not lose its topicality. In case of open and complicated (with infections, osteomyelitis, false joint) fractures, treatment with external fixators has been considered as most of the rational. Among external fixation devices the rod-external fixation apparatus is very comfortable compared to pin-external fixation. With this purpose, has been suggested the rod-external fixation apparatus (patent-office GE p 2000 2067-Bauthor G.Chaduneli) distinguished by high rigidity. Fixation is applied simultaneously on many planes and according to the indication, Schanz's or Steinmann's rods could be used. Of 79 treatment cases, 76 were positive (96,1%).

KEYWORDS: long tubular bones, fractures, external fixation apparatus

According to the statistical data, during the late decade, in economically developed countries the reducing tendency of traumas has not been detected. Moreover, increases frequency of serious traumatic injuries such as multiple, comminuted, splintered and open fractures. Fractures of long tubular bones of lower limbs constitute for about 36,6% of all fractures. Of them, 12-15% are open fractures. Various methods have been suggested for their treatment. Operational methods involve use of both, internal and external fixation.



Fig.1 Chaduneli apparatus.

In modern traumatology, selection of treatment methods and tactics is quite topical and problematic especially when there is open and complicated (with infections, osteomyelitis, false joint) fractures, since quality, effect and outcome of treatment to a great extent depend on the well-selected methods.

Unfortunately, very often, treatment of fractures with traditional methods is unable to avoid such kind of complications as purulent-necrotic infections of soft tissues, osteomyelitis, non-union fractures. Sometimes these complications lead to the gangrene and amputation of extremities. Complete recovery in case of lower limb fractures vary from 3 to 7 months and sometimes even from 9 to 10 months.

According to the various authors, disability constitute from 5,1% to 39,9%. In case of open and complicated fractures majority of authors consider and prefer non-focal osteosynthesis i.e. fixation with external fixative devices as most of the rational methods of treatment

Among external fixation devices the rod-external fixation apparatus is very comfortable for its montage simplicity however, it also include certain insufficiency. This concerns to fixation quality, they have relatively low fixation rigidity, which is determined by unilateral or one plane fixation of bones.

Have been studied positive and negative sides of most of the widely used rod-external fixation apparatus (External fixator of tubular system- Switzerland firm "Synthes", AO, Wagner lengthening apparatus – Germany "Aescylap Denhem external fixation system – Great Britain, Kronner external fixator USA, Fixateur externe du scruice de sante des armes France etc.). Investigations have shown that perfection of their constructions is not completed and limited.

We were aimed to increase maximally the bone fragments' fixation quality of rod-external fixation apparatus that would be simple, universal and could significantly reduce and avoid various complications.

With this purpose has been used external fixation apparatus invented and suggested by G.Chaduneli (valid since 1998, 2200/01, patent-office GE p 2000 2067-B).

Apparatus fixes on the already existing screw-type rods of Schunz and Shteiman's type penetrating smooth rods. Fixation is applied on many planes that provides especially stabile and firm fixation of bone fragments.



Fig.2 Hoffmann apparatus.

The tasks of the work were:

1. Study and detection of technical aspects of the apparatus on the basis of biomechanical investigations.
2. Indication for use of certain apparatus in such case, where abilities of other devices (internal fixators of tissues) have been expired. It concerns to the open (gunshot injury) and complicated fractures.
3. Perfection of usage and advantages of apparatus in case of closed fractures, especially in case of metaepiphyseal, multiple and comminuted fractures compared to the internal fixation.
4. Study of clinical effects and treatment results.

MATERIAL AND METHODS

A total of 79 patients underwent examination. They were treated in the J.C. clinic "Travmatologi" and other clinics as well with the use of apparatus suggested by G.Chaduneli. The object of investigation was the treatment process of bone fractures. The methods of investigation were informative, biomechanical, clinical, laboratory, X-ray and statistical.

Practical value: The construction of presented apparatus is characterized by wide functional abilities; first was elaborated the apparatus that prevents displacement of bone fragments. The latter permits use of early functional and dosaged loads on injured limbs. Patients are mobile, can lift the injured limb independently and walk with the use of crutch in a few hours after operation; significantly are reduced periods of treatment and disability: practically on the 2nd day after operation all patients can be treated as outpatients. The apparatus, owing to its technical constructions, uses existing standard rods. Apparatus includes such positive elements that present in pin apparatus in the form of metal arches. It provides spatial disposition of the rods.

Apparatus can be constructed using the metal rings and screw-type pins during the operation considering type of fracture. The standard rods are inserted directionally as they are requested (according to the indication) and due to ability to move the fixation nodes all types of bone fractures (multiple, metaepiphyseal) can be fixed.

The suggested apparatus is simple and can be used in urgent cases. The bone fragments are fixed simultaneously in several planes that significantly increase treatment quality and make conditions for acceleration of regenerative reparation processes, increases local tissue immunity and existing infectious processes underwent arrest; favorable conditions for bone fragments' consolidation are created.

The scientific novelty: the present work suggests newest information about load distribution of system "Apparatus – bone fracture fragments" and bone fragments' dislocation that are produced at applying of apparatus on injured limb.

Have been stated the forces applied on apparatus and fractured bone fragments during axial load. Redistribution of forces among apparatus and fractured bones depends on fixation quality, which in turn determined by rigidity of fixation. Such type of index could be accepted for evaluation of reliability of bone fragments' fixation.

This method for detection of rigidity index could be applied for other apparatus as well.

$$\text{Formula of rigidity: } K_{rig.} = 1 \div \frac{\Delta p}{p}$$

Where p is the external longitudinal load, $\Delta p(\Delta)$ – load at the line of fracture. For measurement and registration of force Δ at the line of fracture, the special device has been elaborated.

With this purpose experiments have been carried out on bones (cow) with two fractures. Each bone fragment was fixed using the Chaduneli apparatus. Between the bones spring was placed as a dynamometer. Spring (dynamometer) was examined on longitudinal load and its contraction diagram was created (in diapason from 0 to 1000 newton). The received diagram was compared to the data obtained by known formula of spring contraction.

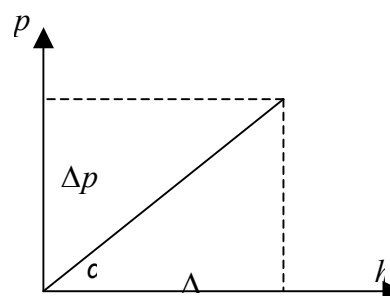


Fig.3 Correlation of the external longitudinal load (p) and displacement of bone fragments (h).

$$\Delta h = \frac{8pG^3n}{Gd^4}, \text{ Where } d \text{ is the diameter of spring's wire,}$$

D - the diameter of spring, n – number of spring's functional turns (loops), G – module ($G=8 \cdot 10^{10}$ n/m²).

Experiments have been carried out on two apparatus in the same conditions for load. Results have shown on the Fig.4.

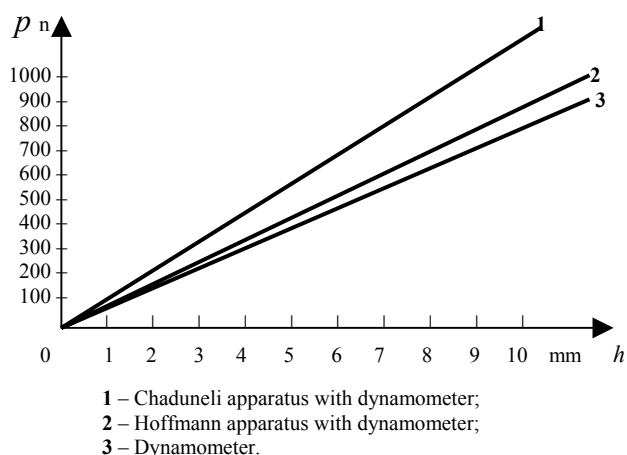


Fig.4 Diagrams of the experiments.

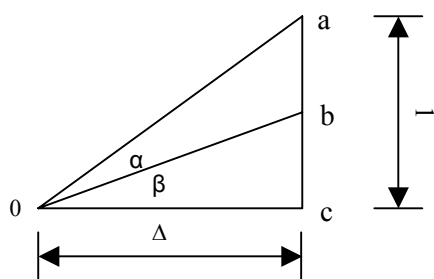


Fig.5 Graphic expression of the bone fragments displacement after external longitudinal load.

For calculation of rigidity index the results of experiments have been analyzed according to the Fig.5.

$$K_{rig.} = ab = ac - bc = 1 - bc = \Delta tg\alpha - \Delta tg\beta$$

Results of experiments have been processed according to the calculation of the square of rigidity index:

$$K_{rig.} = \sqrt{\frac{\sum K_{rig.i}^2}{n}}$$

Where $K_{rig.}$ is the rigidity index for i load and n case of load.

Rigidity index of Chaduneli apparatus:

$$K_{rig.} = ab = \sqrt{\frac{0,3334^2 + 0,3385^2 + 0,337^2}{3}} \approx 0,3363$$

is more than rigidity index of Hoffmann apparatus:

$$K_{rig.} = ab = \sqrt{\frac{0,1817^2 + 0,2001^2 + 0,2041^2}{3}} \approx 0,1955$$

$$K_{rig.} = 0,3363 > 0,1955.$$

p (n)	Δ (mm)	Δ_1 (mm)	$\Delta' = ctga = \Delta/p$	$tga = \Delta/p$	$tg\beta = p/\Delta_1$	ac	bc	ab
200	2,2	3,3	0,011	90,909	60,606	1	0,6666	0,3334
400	4,3	6,5	0,01075	93,023	61,538	1	0,6615	0,3385
600	6,5	9,8	0,01083	92,308	61,224	1	0,663	0,337
800	8,2	-	0,01025	97,560	-	1	-	-

Tab.1 Indices of Chaduneli apparatus with dynamometer.

p (n)	Δ (mm)	Δ_1 (mm)	$\Delta' = ctga = \Delta/p$	$tga = \Delta/p$	$tg\beta = p/\Delta_1$	ac	bc	ab
200	2,7	3,3	0,0135	74,074	60,606	1	0,8182	0,1817
400	5,2	6,5	0,013	76,923	61,538	1	0,7999	0,2001
600	7,8	9,8	0,013	76,923	61,224	1	0,7959	0,2041
800	-	-	-	-	-	1	-	-

Tab.2 Indices of Hoffmann apparatus with dynamometer.

CONCLUSIONS

1. Owing to suggested and clinically approved apparatus of external fixation have been received significant clinical and economical effects during treatment of fractures. The apparatus has high rigidity index. Wide use of the mentioned apparatus in urgent traumatology would be of great value in treatment of open, comminuted and complicated fractures. Has been stated its advantages at treatment of closed fractures. It concern to the metaepiphyseal and multi-fragmental fractures, when use of internal fixators has no effect and causes additional traumatization of bone tissue. The suggested method provides patient's early mobilization and due to the firm fixation they do not feel pain, moreover using the crutch, they can walk in few days after operation.

- The most optimal indication for the use of suggested apparatus is the open (gunshot injury) and complicated fractures, when nonfocal osteosynthesis is considered as most of the rational.
- Of 79 treatment cases, 76 were positive (96,1%). In two cases – additionally was used other method, and in 1 case – infectious process was not arrested.
- Comparison of the results, obtained after experiments, have shown that rigidity index of Chaduneli apparatus $K_{rig.} = 0,3363 > 0,1955$ is more than rigidity index of Hoffmann apparatus.
- Thus, could be concluded that Chaduneli apparatus is more rigid and able to withstand more load than others, and complications will be less during treatment.

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Лечение длинных трубчатых костей аппаратом внешней фиксации

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Р Е З Ю М Е

В современной травматологии выбор оптимальных методов лечения переломов длинных трубчатых костей, особенно открытых, сложных и множественных, не теряет своего значения. В случае открытых и сложных (наличие инфицирования, остеомиелита, ложных суставов) переломов, лечение аппаратом нарушенной фиксации считается наиболее рациональным. В числе приемов наружной фиксации аппараты стрессовой наружной фиксации особенно удобны. Эксперимент показал, что аппараты наружной фиксации (Patent-office GE р 2000 2067-Bauthor G.Chaduneli) отличаются очень высокой прочностью. Фиксация была применена одновременно на многих плоскостях и стрессовые Шварца и Стеинмена надежность в применении. Из 79 случаев лечения 76 были позитивны (96,1%).

Ключевые слова: длинные трубчатые кости, переломы, аппарат наружной фиксации

□ **International committee of medical journal editors. Uniform requirements for manuscripts submitted to biomedical journals.** *Ann Intern Med* 1997;126:36-47.

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